

ANNEX NO. 2  
BETWEEN  
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
GLENN RESEARCH CENTER  
AND  
SPACE EXPLORATION TECHNOLOGIES CORP.  
UNDER  
REIMBURSABLE SPACE ACT UMBRELLA AGREEMENT SAA3-1708

ARTICLE 1. PURPOSE

NASA Glenn Research Center (GRC) and Space Exploration Technologies Corp. ("Partner" or SpaceX) enter into Annex No. 2 for the purpose of conducting environmental tests on SpaceX's extended fairing to include electromagnetic interference ("EMI") testing, modal testing, and a series of separation tests. Testing will take place at the NASA Glenn Research Center, Armstrong Test Facility ("ATF").

NASA GRC offers world class facilities, NASA expertise, and experienced staff in the area of space environments testing, which makes the facilities uniquely suited to provide such large-scale test capability. A strong relationship with SpaceX and a history of executing successful testing campaigns has already been demonstrated. In addition, the ATF specifically has experience with large scale testing of complex space systems for the commercial sector and for large programmatic test programs.

ARTICLE 2. RESPONSIBILITIES

A. NASA GRC will use reasonable efforts to:

In support of the EMI Test:

1. Provide an electromagnetically shielded test chamber for the EMI testing that provides RF shielding of approximately 67 dB in the range from 100 MHz to 40 GHz for two test series.
  - a. Empty EMI Chamber to characterize.
  - b. Encapsulated payload fairing to characterize fairing (2 configurations).
2. Provide EMI test engineer and technicians to support test buildup and testing.
3. Provide access to an existing scissor lift from the Space Environments Complex ("SEC") lift inventory noted in Section 10 of the SEC Capabilities and Interfaces Document ("SCID") Part II: Facility Infrastructure.
  - a. Lift will be used in the EMI chamber to mount the external RF antennae, allowing movement for various configurations.
  - b. SpaceX will be responsible for rental of any lift (aerial or scissor) if the existing inventory of lifts do not meet the height/access requirements.
4. Provide existing facility overhead cranes (including the vacuum chamber 20-ton overhead polar trolley crane, 10-ton auxiliary crane) for positioning test article and fixtures in the chamber. SpaceX will need to provide/rent a mobile crane if required.
5. Provide deconfiguration of the EMI chamber shielding treatments in preparation for payload fairing jettison testing under vacuum.

6. Provide SpaceX with a detailed test report after each test.

In support of the Modal Test:

1. Provide access to 120-volt single phase power and 480-volt three phase power for Partner supplied excitation, instrumentation, and data acquisition equipment.
  - a. SEC has two available Data Acquisition Systems. The Mobile Data Acquisition System (“MDAS”) must be used for the suspended modal test in the Thermal Vacuum (“TVAC”) chamber.
    - i. Facility Data Acquisition System (FDAS).
      1. 1,024 channels,  $\pm 10$  V.
      2. 50,000 Samples/sec on all channels.
      3. DC to 20kHz, alias free measurement bandwidth.
    - ii. MDAS.
      1. 256 channels,  $\pm 10$  V
      2. 256,000 samples/sec on all channels.
      3. DC to 111kHz, alias free measurement bandwidth.
2. Provide access to the SEC Modal plate, a 6” thick steel slab with a stiffness of  $11 \times 10^6$  lb/in mounted to a 4.5-million-pound seismic mass
3. Provide existing modal floor threaded anchor locations per NASA SEC drawings PE-43183 and PE-43188
4. Provide access to the SEC Vibroacoustic Crane (30 Ton) and SEC cranes (including the vacuum chamber 20-ton overhead polar trolley crane, 10-ton auxiliary crane) to perform suspended modal testing of half of the payload fairing, depending on desired location
5. Modal testing will be done with payload fairing in its encapsulated position on the SEC modal plate along with half of the payload fairing suspended from the facility Polar Crane located in the Vacuum Chamber. Testing will also be performed on just the payload adapt fittings, positioned on the modal plate.

In support of the Separation Test:

1. Provide the SEC and associated equipment and conduct four (4) rough-vacuum pump-downs to support fairing separation tests. This includes a vacuum dry run prior to the first separation test
  - a. It is noted that Space X is requesting four (4) fairing separation tests.
2. Provide qualified personnel to operate the NASA GRC and associated facilities and sub-systems.
  - a. Provide support for a single 12-hour shift (7am-7:30pm) Monday – Saturday during pre/posttest periods.
  - b. SEC will staff 24/7 during the Vacuum Dry Run and Separation tests.
    - i. Vacuum System pump down will begin at 7 am the day of each test and will staff Vacuum Pump down Crew, Video Operator, Data Engineering/Tech from 7am -7:30 pm.
    - ii. Small crew will work 7 pm – 7:30 am to repress TVAC chamber and open Doors 5 and 7 (Personnel Access) after SpaceX provides break of configuration.
3. Provide the use of existing SEC man-lift and fork-lift equipment per SCID Part II: Facility Infrastructure based on availability.
  - a. SpaceX to provide qualified operators who are certified on similar equipment

- (some qualification required),
- b. SEC will provide onsite familiarization training for equipment.
4. Provide visibly clean test chamber, non-condensable environment.
  5. Provide existing facility cranes (including the vacuum chamber 20-ton overhead polar trolley crane, 10-ton auxiliary crane) for positioning test article and fixtures in chamber.
  6. Provide mutually agreed upon data (digital test data files and test file printouts, video recordings, still photographic recordings) of the test in the form of a separate Data Plan agreed between SpaceX and SEC.
  7. Conduct a joint Operational Readiness Review prior to each test series
    - a. EMI,
    - b. Modal,
    - c. Fairing Separation Testing.
  8. Conduct a joint Test Safety Review for all test series.
    - a. Test Safety Review and Hazards will be provided per Glenn Procedure GLP-QS-8715.1.1, GRC Safety Manual
  9. Provide existing vacuum chamber load-rated and proof-tested attachment points per Drawing PE-1411-00044REF-M-401
    - a. Includes eight (8) elevated “dome” hardpoints and multiple threaded patterns on East/West Aluminum Door portals.
    - b. Includes chamber floor hardpoints, threaded inserts.
    - c. NASA will review and structurally evaluate SpaceX arresting/restraint loads input to the facility. SpaceX shall design all catch rigging and supply the resultant peak dynamic loads to NASA for facility allowable load evaluations.
  10. Collaborate with SpaceX with instrumentation end-to-end checks for customer response instrumentation.
  11. Collaborate with SpaceX regarding chamber pressure measurements.
  12. Logistics assumptions:
    - a. Approximate 4-month occupancy (covers all separation build up/test/teardown operations).
    - b. The vacuum chamber will have the two cryoshroud masts and four vertical wall panels and supporting link arms installed during test. The four vertical wall panels will be rotated towards inner wall of test chamber to provide maximum clearance for separation testing.
    - c. One pump-down for each separation test to 0.1 Torr (Per SpaceX).
      - i. Prior to first separation test SEC will provide one ‘ambient’ pressure operational dry run followed by one operational dry run at desired chamber pressure of 0.1 Torr.
      - ii. Pending analysis, chamber pressure of 1 Torr will be allowed for the vacuum dry run and certain test runs.
    - d. Fairing panels catch systems designed/tested/built/assembled/installed by SpaceX personnel.
  13. Inventory existing on-site SpaceX hardware agreed to be held at the SEC from prior test campaigns (intended for use on future campaigns).
    - a. This includes multiple counterweights, cable harnesses, misc. restraint/bounce-back system structural components, and test article elevated ground support structure.
    - b. SEC will require SpaceX to inspect and verify any identified hardware.
  14. Provide special test equipment, whose major components consist of:
    - a. Time-base generator (IRIG B) for data and video recordings (can be provided to

customer as well).

- b. Provide rental from an external entity of up to five (5) high speed cameras at 1000 fps, lenses, software to capture/record/post process and the remote triggering system. Cameras will be rented for a period of 3 months. All high-speed cameras are black and white.
- c. Provide one 'public relations' type high-definition, 30 fps video camera.
- d. Provide the MDAS with the below capabilities:
  1. 256 channels, +/- 10V.
  2. 256,000 samples/sec on all channels.
  3. DC to 111kHz, alias free measurement bandwidth.
- e. Provide use of existing chamber feed-through penetration bulkhead connectors and existing cabling to the high-speed data acquisition system. This cabling may not be of the correct type or quantity required to conduct the SpaceX test.
- f. Provide facility-side instrument connectors, existing feedthroughs, and signal conditioning equipment.
- g. Provide existing high-intensity lighting, existing scaffolding towers x2 (for mounting lighting and cameras).
15. Provide up to 12 offices at SEC, meeting room space, telecommunications equipment (phone, facsimile, public internet access).
16. Upon Partner's request, SEC will provide an ordinance storage bunker to store all SpaceX-required ordinance until time of use.
  - a. Bunker is approximately 1789 square feet can be used for storage of Class 2 explosives (pyrotechnics).
  - b. The bunker is located approx. ¼ mile from the SEC facility.
  - c. The bunker is used only to store detonators and initiators.
  - d. The bunker is not temperature or humidity controlled but remains cool due to the design of the earth-covering and concrete walls and floors. Initiators and detonators stored in the bunker should be housed in their own humidity-controlled containers provided by SpaceX. If the equipment is required to be maintained at temperature, the Customer will need to supply the appropriate equipment. The bunker is designed per DOD 6055.9, Chapter 5. The customer and NASA Safety Representatives must ensure that materials are compatible and can be stored in the same location, otherwise additional storage space may be required.
17. Provide SpaceX with a detailed test report after each test.
18. Upon Partner's request, SEC will provide a chamber feed-through location for pressurizing the internal volume of the fairing with atmospheric air. SpaceX and NASA to collaborate regarding the details of the approach to pressurize the fairing.

B. Partner will use reasonable efforts to:

1. Provide Critical Lift Plans for all identified critical lifts per Glenn Procedure, GLP-QS-8715.1.20, GRC Safety Manual Chapter 20 Lifting Devices and Equipment.
  - a. Critical Lift Plans shall be provided to NASA for review and acceptance by the GRC Lifting Devices and Equipment Manager and SEC Engineering.
  - b. SEC Engineering can provide a Critical Lift Plan template and list of requirements.
2. Provide all instrumentation and data that SpaceX considers to be Quality and Safety Critical to SEC.

3. Provide all response instrumentation, attached to the test article and fixtures, with appropriate cables/connector(s) to connect to the existing chamber feedthroughs.
4. Provide technical information required to support test operations at NASA (Statement of Work, Test Configuration Drawings, Test Plan, Schedule).
5. Provide all Test Procedures to GRC-SEC for review and coordination.

In support of the EMI Test:

1. Provide dual ridge guide (DRG) horns and log-periodic low band antennae and applicable ground support equipment and cabling for both internal (within PLF) and external transmission and receiving.
2. Provide the Vector Network Analyzer and other required equipment (fiber optic lines, spectral analyzers etc.) to perform the two-test series.
3. Provide Ground Support Equipment to support payload fairing and EMI equipment NASA-STD-5005D, NASA TECHNICAL STANDARD: STANDARD FOR THE DESIGN AND FABRICATION OF GROUND SUPPORT EQUIPMENT (GSE).
4. Provide a request for all SEC onsite equipment that SpaceX intends to use during test buildup/testing so SEC may determine its availability.
5. Provide personnel to perform test buildup and execution.
6. Provide Data Acquisition Systems for test series.
7. Provide EMI test procedures.

In support of the Modal Test:

1. Provide personnel to perform test buildup and execution.
  - a. Includes all ground support equipment for all lifts.
2. Provide the instrumentation and data acquisition systems for modal testing.
3. Provide a mobile crane if required to set the test article on the modal plate due to possible overhead bridge crane height limitations.
4. Provide estimated floor loads induced by mobile crane wheels and outriggers, if used, so NASA can evaluate structural loading on the facility floor locations.

In support of the Separation Test:

- 1) Provide test article elevated ground support fixture.
  - a. Ground support equipment shall comply with NASA-STD-5005D, NASA TECHNICAL STANDARD: STANDARD FOR THE DESIGN AND FABRICATION OF GROUND SUPPORT EQUIPMENT (GSE).
- 2) Provide fairing 'catch' or 'arresting' system(s) as needed to safely capture and contain the separated fairings prior to impacting any part of the vacuum chamber including floors, walls, door portals or cryoshroud.
  - a. Provide separation dynamic analysis documentation for SEC Engineering review; Analysis will include anticipated loading (peak dynamic) on any SEC Test Chamber Hardpoints. NASA will evaluate the structural loads induced by SpaceX onto the chamber hardpoints based on the peak dynamic loads provided by SpaceX dynamic analyses.
  - b. Fairing 'catch' or arresting system(s) shall comply with NASA-STD-5005D, NASA TECHNICAL STANDARD: STANDARD FOR THE DESIGN AND FABRICATION OF GROUND SUPPORT EQUIPMENT (GSE) regarding design and rated load safety factors.

- 3) Provide all ordinance handling personnel for explosive materials.
  - a. SpaceX shall provide an Explosive Site Plan and collaborate with the GRC Explosive Site Officer (ESO) to be granted a GRC Site License for Explosives, Propellants and Pyrotechnics per the GRC Safety Manual Chapter 18 Explosives, Propellants and Pyrotechnics.
- 4) SpaceX to provide qualified operators who are certified on similar equipment (some qualification required) listed in SCID Part II (eg: man-lift and fork-lift equipment).
- 5) SEC requires SpaceX to inspect and verify any identified hardware from inventory list that is intended for use in this test campaign
- 6) Provide cabling / connectors from chamber feed-through penetrations to the high-speed data acquisition system should the use of existing bulkhead connectors and cabling not be of the correct type or quantity required to conduct the SpaceX test.

### ARTICLE 3. SCHEDULE AND MILESTONES

The planned major milestones for the activities for this Annex defined in the "Responsibilities" Article are as follows:

1. SpaceX arrival to SEC facility to start test preparation.      On or about May 2023
2. Completion of the full suite of testing defined by the      On or about September  
responsibilities above with a 16-week consecutive test      2023  
window. As discussed with SpaceX, planned SEC  
facility commitments on either side of this test window  
could impact the 16-week test duration.

### ARTICLE 4. FINANCIAL OBLIGATIONS

A. Partner agrees to reimburse NASA an estimated cost of \$1,667,304.00 for NASA to carry out its responsibilities under Annex No. 2. Each payment shall be marked with NASA Glenn Research Center, SAA3-1708, Annex No. 2

B. NASA will not provide services or incur costs beyond the current funding. Although NASA has made a good faith effort to accurately estimate its costs, it is understood that NASA provides no assurance that the proposed effort under this Annex will be accomplished for the estimated amount. Should the effort cost more than the estimate, Partner will be advised by NASA as soon as possible. Partner shall pay all costs incurred and have the option of canceling the remaining effort or providing additional funding in order to continue the proposed effort under the revised estimate. Should this Annex be terminated, or the effort completed at a cost less than the agreed-to estimated cost, NASA shall account for any unspent funds within one (1) year after completion of all effort under this Annex, and promptly thereafter, at Partner's option return any unspent funds to Partner or apply any such unspent funds to other activities under the Umbrella Agreement. Return of unspent funds will be processed via Electronic Funds Transfer (EFT) in accordance with 31 C.F.R. Part 208 and, upon request by NASA, Partner agrees

to complete the Automated Clearing House (ACH) Vendor/Miscellaneous Payment Enrollment Form (SF 3881).

#### ARTICLE 5. INTELLECTUAL PROPERTY RIGHTS - DATA RIGHTS

A. Data produced under this Annex which is subject to paragraph C. of the Intellectual Property Rights - Data Rights Article of the Umbrella Agreement will be protected for the period of two years.

B. Under paragraph H. of the Intellectual Property Rights - Data Rights Article of the Umbrella Agreement, Disclosing Party provides the following Data to Receiving Party. The lists below may not be comprehensive, are subject to change, and do not supersede any restrictive notice on the Data provided.

1. Background Data:

The Disclosing Party's Background Data, if any, will be identified in a separate technical document.

2. Third Party Proprietary Data:

The Disclosing Party's Third Party Proprietary Data, if any, will be identified in a separate technical document.

3. Controlled Government Data:

The Disclosing Party's Controlled Government Data, if any, will be identified in a separate technical document.

4. The following software and related Data will be provided to Partner under a separate Software Usage Agreement: None

#### ARTICLE 6. TERM OF ANNEX

This Annex becomes effective upon the date of the last signature below ("Effective Date") and shall remain in effect until the completion of all obligations of both Parties hereto, or three (3) years from the Effective Date, whichever comes first, unless such term exceeds the duration of the Umbrella Agreement. The term of this Annex shall not exceed the term of the Umbrella Agreement. The Annex automatically expires upon the expiration of the Umbrella Agreement.

#### ARTICLE 7. RIGHT TO TERMINATE

Either Party may unilaterally terminate this Annex by providing thirty (30) calendar days written notice to the other Party.

#### ARTICLE 8. POINTS OF CONTACT

The following personnel are designated as the Points of Contact between the Parties in the performance of this Annex.

Management Points of Contact:

NASA

Lynn A. Capadona, Ph.D.  
SEC Senior Project Manager

Space Exploration Technologies Corp.

Brea Yount  
Contracts Officer

Mail Stop: ATF  
21000 Brookpark Road  
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[lynn.a.capadona@nasa.gov](mailto:lynn.a.capadona@nasa.gov)

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Hawthorne, CA 90250  
Phone: 310-682-2813  
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Technical Points of Contact:

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SEC Project Manager  
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ARTICLE 9. MODIFICATIONS

Any modification to this Annex shall be executed, in writing, and signed by an authorized representative of NASA and the Partner. Modification of an Annex does not modify the terms of the Umbrella Agreement.

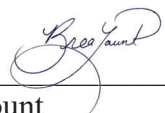
ARTICLE 10. SIGNATORY AUTHORITY

The signatories to this Annex covenant and warrant that they have authority to execute this Annex. By signing below, the undersigned agrees to the above terms and conditions.

NATIONAL AERONAUTICS AND  
SPACE ADMINISTRATION  
GLENN RESEARCH CENTER

SPACE EXPLORATION  
TECHNOLOGIES CORP.

BY: \_\_\_\_\_  
James A. Kenyon, Ph.D.  
Acting Center Director

BY:  \_\_\_\_\_  
Brea Yount  
Contracts Officer

DATE: \_\_\_\_\_

DATE: 8/23/2022 \_\_\_\_\_